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# CONVAIR ASTRONAUTICS

CONVAIR DIVISION OF GENERAL DYNAMICS CORPORATION

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REPORT NO. 27A708

ASTRONAUTICS

EVALUATION TEST OF

VERNIER LIQUID OXYGEN

SYSTEM BURST DIAPHRAGMS

27-24055

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## REVISIONS

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1.0 OBJECT:

- 1.1 The object of this test was to develop a burst diaphragm suitable for service in the vernier liquid oxygen feed system.

2.0 CONCLUSIONS:

- 2.1 A suitable burst diaphragm was developed. The configuration chosen is shown in Dwg. 27-24055-13. Some of the principal factors affecting diaphragm design are listed below:

- a) The diaphragm thickness remaining at the base of the groove is the main factor in determining the burst pressure.
- b) Hinge width helps determine the ability of the diaphragm to remain with the rest of the diaphragm after rupture.
- c) The diaphragm pad thickness determines its ability to fold over against the wall of the line.

3.0 DESCRIPTION OF SPECIMENS:

- 3.1 A total of 210 diaphragms were burst tested. These specimens were divided into eight basic groups. One group consisted of diaphragms per Dwg. 27-24055-13. The seven other groups consisted of generally similar specimens but with specific differences in configuration or methods of fabrication. These eight groups in turn were subdivided into smaller groups of specimens which included variations in the thickness of diaphragm material remaining at the base of the groove, width of the hinge pad, direction of the material grain with respect to the hinge and the test conditions to which they were subjected.

4.0 TEST PROCEDURE:4.1 Burst Test:

- 4.1.1 The test requirements, and consequently the test procedure, were modified considerably during the course of

## 4.1.1

(Cont'd)

the test program. During the first half of the program, the various specimens were filled with liquid nitrogen and slowly pressurized to failure with nitrogen gas. During the second half of the test program, specimens were burst tested by one of the following methods:

- a) Slowly pressurizing the specimen to failure with nitrogen gas.
- b) Subjecting the specimen to a nitrogen gas impact load (press. rise approx. 30 psi per millisecond)
- c) Slowly pressurizing the liquid nitrogen filled specimen with nitrogen gas.
- d) Partly filling the specimen with liquid nitrogen and slowly pressurizing with nitrogen gas.
- e) Partly filling the specimen with liquid nitrogen and applying an impact load with nitrogen gas. In addition, three burst tested specimens were subjected to a water flow test of approximately 16 gallons per minute for 45 minutes.

## 4.2

Test Equipment:

- a) Pressure Gage by ACCO Helicoid, 0-60 psi range, 1/2 psi increments, Ser. No. 968
- b) Pressure Gage by ACCO Helicoid, 0-300 psi range, 2 psi increments, Ser. No. 999
- c) Pressure Gage by ACCO Helicoid, 0-400 psi range, 5 psi increments, Ser. No. 974
- d) Pressure Gage by ACCO Helicoid, 0-1000 psi range, 10 psi increments, Ser. No. 80
- e) Pressure Gage by Ashcroft, 0-2000 psi range, 20 psi increments, Ser. No. 1737
- f) Pressure Regulator by Victor, 0-4000 psi inlet range, Ser. No. 893, 0-4000 psi outlet range, Ser. No. 892

4.2

(Cont'd)

- g) Pressure Transducer by Statham, 0-1000 psi range, Ser. No. 6369
- h) Valves by Security, Model 25020, Ser. No.'s M101 and M102
- i) Valve- Solenoid by Marotta, Type MV-36, Ser. No. 1647
- j) Recorder by Sanborn, Model 150, A.F. 765360-2.

5.0

DISCUSSION AND RESULTS:

5.1

Test results are shown in Tables 1 through 4. A graphic representation of the test results is shown in Graphs 1 through 4. Burst diaphragms to be used on the missile will conform to Convair Dwg. No. 27-24055-13. This diaphragm includes the following features:

- a) Hinge width of 0.25 in.
- b) Basic diaphragm thickness of 0.025 in.
- c) Material thickness remaining at the base of the groove varying between 0.004 and 0.005 inches
- d) Diaphragm grain direction- perpendicular to hinge

All of these dimensions and factors were varied during the test program. Additional variables included coined or machined grooves, rectangular or hemispherical shaped grooves, and various diaphragm pad patterns in the vicinity of the hinge. A rectangular-shaped, machined groove, terminating abruptly at the hinge, was chosen as the final configuration.

It was noted that the rupture pressure varied directly with the thickness of the diaphragm material remaining at the base of the groove. Impacting the specimen generally increased the rupture pressure by 100 to 200 psi. It was difficult to note the precise rupture pressure because the pressure continued to rise for a short time after impact type rupture. In these cases rupture pressure was considered to have occurred at the point where the slope of the pressure vs. time curve changed perceptibly. High rupture pressures sometimes resulted in cracked hinges. A low rupture pressure often resulted

## 5.1 (Cont'd)

in an incomplete folding of the diaphragm pad. Because of these difficulties a wide hinge and a thin diaphragm were used.

## 6.0

DATA BOOK REFERENCE:

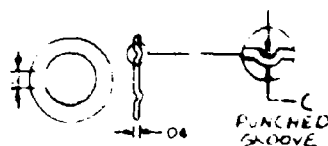
This report was prepared from test data recorded in Test Labs Engineering Note Book No. 7343.

TABLE I

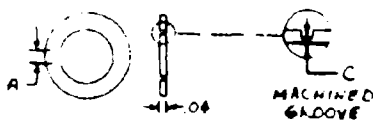
VERNIER LIQUID OXYGEN BURST DIAPHRAGM  
BURST TEST RESULTS

## NOTES:

- 1 SPECIMEN MAT'L 5052-H34 AL ALLOY
- 2 SPECIMENS WERE BURST TESTED BY FILLING THE SYSTEM WITH LIQUID NITROGEN AND SLOWLY PRESSURIZING TO FAILURE



DESIGN GR IDEN NO	TEST LAB IDEN NO	DIM C (INCHES)	BURST PRESS. (PSIG)	COMMENTS	DESIGN GR IDEN NO	TEST LAB IDEN NO	DIM C (INCHES)	BURST PRESS. (PSIG)	COMMENTS
—	1	006	—	PRESS TO 375 PSIA NO FAILURE	X	8	0028 004	250	
—	2	008	580		X	9	0028 004	295	
—	3	SPECIMEN NO 3 HAS A SPECIAL DIMPLED DIAPHRAGM PRESS TO 800 PSI WITHOUT FAILURE			0	10	004 005	180	PAD NOT COMPLETELY FOLDED
—	4	001	220		0	11	004 005	170	PAD NOT COMPLETELY FOLDED
—	5	001	185	PAD TORE LOOSE AT WING	0	12	004 005	205	PAD NOT COMPLETELY FOLDED
X	6	0028 004	360		—	13	002	145	PAD NOT COMPLETELY FOLDED
X	7	0028 004	280		6	25	004	—	PRESS TO 400 PSI NO FAILURE



DESIGN GR IDEN NO	TEST LAB IDEN NO	DIM A (INCHES)	DIM C (INCHES)	BURST PRESS. (PSIG)	COMMENTS	DESIGN GR IDEN NO	TEST LAB IDEN NO	DIM A (INCHES)	DIM C (INCHES)	BURST PRESS. (PSIG)	COMMENTS
1	14	.12	001	40	PAD NOT COMPLETELY FOLDED	7	27	.125	003	170	PAD FOLDING INCOMPLETE
1	15	.12	001	30	PAD NOT COMPLETELY FOLDED	8	28	.157	008	145	PAD FOLDING INCOMPLETE
4	20	.12	002	105	PAD FOLDING INCOMPLETE	8	29	.187	003	190	PAD FOLDING INCOMPLETE
4	21	.12	002	125	PAD FOLDING INCOMPLETE	8	30	.187	003	115	PAD FOLDING INCOMPLETE
5	22	.18	002	80	PAD FOLDING INCOMPLETE	9	31	.25	003	155	PAD FOLDING INCOMPLETE
5	23	.18	002	90	PAD FOLDING INCOMPLETE	9	32	.25	003	145	PAD FOLDING INCOMPLETE
6	24	.125	002	140	PAD FOLDING INCOMPLETE	10	33	.157	004	230	
7	26	.125	003	125	PAD FOLDING INCOMPLETE	10	34	.187	004	215	PAD FOLDING INCOMPLETE



TABLE II

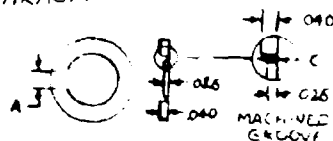
## VERNIER LIQUID OXYGEN BURST DIAPHRAGM

## BURST TEST RESULTS

## NOTES:

1. SPECIMEN MATL 5052H-34 AL. ALLOY

2. SPEC. 35-47 WERE FILLED WITH LIQUID NITROGEN &amp; SLOWLY PRESSURIZED TO FAILURE



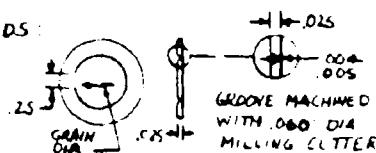
DESIGN GR IDEN. NO	TEST LAB IDEN. NO	DIM. A (INCHES)	DIM. C (INCHES)	BURST PRESS (PSIG)	COMMENTS	DESIGN GR IDEN. NO	TEST LAB IDEN. NO	DIM. A (INCHES)	DIM. C (INCHES)	BURST PRESS (PSIG)	COMMENTS
11	35	12	003	155	PAD FOLDING INCOMPLETE	13	42	18	003	50	PAD FOLDING INCOMPLETE
11	36	12	003	150	PAD FOLDING INCOMPLETE	13	43	18	003	230	
11	37	12	003	100	PAD FOLDING INCOMPLETE	13	44	18	003	60	PAD FOLDING INCOMPLETE
12	38	12	004	160	PAD FOLDING INCOMPLETE	14	46	18	003	110	PAD FOLDING INCOMPLETE
12	39	12	004	145	PAD FOLDING INCOMPLETE	14	45	18	004	295	
12	40	12	004	120	PAD FOLDING INCOMPLETE	14	47	18	004	310	
13	41	18	003	70	PAD FOLDING INCOMPLETE						

NOTE: SPEC 180-189 WERE BURST BY ONE OF THE FOLLOWING METHODS:

(A) SLOWLY INC NI GAS PRESS, (B) IMPACTING SPEC WITH NI GAS

(C) SLOWLY INC PRESS OF SPEC PARTLY FILLED WITH LIQUID NITROGEN

(D) IMPACTING SPECIMEN PARTLY FILLED WITH LIQUID NITROGEN



DESIGN GR IDEN. NO	TEST LAB IDEN. NO	BURST TEST CONDITION	BURST PRESS (PSIG)	COMMENTS	DESIGN GR IDEN. NO	TEST LAB IDEN. NO	BURST TEST CONDITION	BURST PRESS (PSIG)	COMMENTS
6174	180	STATIC NITROGEN GAS	320		6174	185	STATIC LIQUID NITROGEN	290	
6174	181	STATIC NITROGEN GAS	290		6174	186	STATIC LIQUID NITROGEN	295	
6174	182	STATIC NITROGEN GAS	275	CRACKED HINGE	6174	187	STATIC LIQUID NITROGEN	320	
6174	183	NITROGEN GAS IMPACT	320		6174	188	LIQ NI & NI GAS IMPACT	410	SEVERELY CRACKED HINGE
6174	184	NITROGEN GAS IMPACT	325	SEVERELY CRACKED HINGE	6174	189	LIQ NI & NI GAS IMPACT	260	

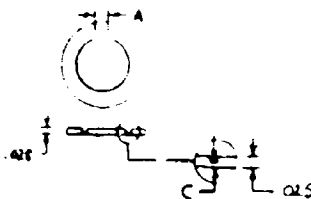
TABLE III (1 of 3)

## VERNIER LIQUID OXYGEN BURST DIAPHRAGM

## BURST TEST RESULTS

## NOTES:

- 1 SPECIMEN 1941 L 5052 H 34 AL 4100
- 2 SPECIMENS 48-75 WERE BURST TESTED BY FILLING THE SYSTEM WITH LIQUID NITROGEN AND SLOWLY PRESSURIZING THE SPECIMEN TO FAILURE



DESIGN GR IDEN NO.	TEST LAB IDEN NO.	DIM A (INCHES)	DIM C (INCHES)	BURST PRESS (PSIG)	COMMENTS	DESIGN GR IDEN NO.	TEST LAB IDEN NO.	DIM A (INCHES)	DIM C (INCHES)	BURST PRESS (PSIG)	COMMENTS
1A	48	125	003	105	HAD FOLDING INCOMPLETE	1C	70	18	004	200	
1A	49	125	003	110	HAD FOLDING INCOMPLETE	1C	71	18	004	190	
1A	50	125	003	40	HAD FOLDING INCOMPLETE	1C	76	18	004	230	
1A	51	125	003	70	HAD FOLDING INCOMPLETE	1C	77	18	004	230	
1A	52	125	003	100	HAD FOLDING INCOMPLETE	1C	78	18	004	205	
1B	54	18	003	190			79	18	004	195	
1B	55	18	003	185			80	18	004	160	
1B	56	18	003	150	HAD FOLDING INCOMPLETE		81	18	004	SPEC PRESS TO 450 PSI (NO BURST)	
1B	57	18	003	160			82	18	004	155	
1B	58	18	003	205			83	18	004	110	
1C	72	18	003	230			84	18	004	155	
1B	73	18	003	255			85	18	004	320	
1B	74	18	003	260			86	18	004	155	
1B	75	18	003	295			87	18	004	195	
1C	59	125	004	175			88	18	004	180	
1C	60	125	004	270			89	18	004	195	
1C	61	125	004	165			90	18	004	230	
1C	65	18	004	155			91	18	004	220	
1C	66	18	004	175			92	18	004	265	
1C	67	18	004	390			93	18	004	210	
1C	68	18	004	SPEC PRESS TO 500 PSI (NO BURST)			94	18	004	165	
1C	69	18	004	240			95	18	004	215	

TABLE III (2 OF 3)

## NOTES: VERNIER LIQUID OXYGEN BURST DIAPHRAGM BURST TEST RESULTS

1. SPECIMENS 105, 116, 112 WERE SUBJECTED TO A WATER FLOW TEST OF APPROX. 16 GAL./MIN FOR 45 MIN. AFTER BURST TEST THERE WAS NO APPARENT DAMAGE.
2. MAT'L GRAIN OF SPEC. 130-137 WAS PARALLEL TO HINGE RANDOM IN EARLIER SPECIMENS.
3. SPEC. 96-115 & 125-129 WERE BURST TESTED BY FILLING THE SYSTEM WITH LIQUID NITROGEN AND SLOWLY PRESSURIZING THE SPECIMEN TO FAILURE. THE REMAINING SPECIMENS OF TABLE 3 WERE TESTED BY ONE OF THE FOLLOWING METHODS (a) SLOWLY INCREASING NITROGEN GAS PRESS. (b) IMPACTING SPECIMEN WITH NITROGEN GAS. (c) PARTLY FILLING SPECIMEN WITH LIQUID NITROGEN & SLOWLY INCREASING NITROGEN PRESS. (d) PARTLY FILLING SPECIMEN WITH LIQUID NITROGEN & IMPACTING SPEC. WITH NITROGEN GAS (EXCEPT SPECIMENS 116-124 WHICH WERE FULL OF LIQUID NITROGEN).

DESIGN OR IDEN. NO.	TEST LAB IDEN. NO.	DIM. A (INCHES)	DIM. C (INCHES)	BURST PRESS. (PSIG)	COMMENTS	DESIGN OR IDEN. NO.	TEST LAB IDEN. NO.	DIM. A (INCHES)	DIM. C (INCHES)	BURST TEST CONDITIONS	BURST PRESS. (PSIG)	COMMENTS
—	96	18	.004	215		—	116	18	.004	LIG. NI & NI GAS IMPACT	320	
—	97	18	.004	225		—	117	18	.004	LIG. NI & NI GAS IMPACT	465	
—	98	18	.004	160		—	118	18	.004	LIG. NI & NI GAS IMPACT	320	
—	99	18	.004	215		—	119	18	.004	LIG. NI & NI GAS IMPACT	240	
—	100	18	.004	190		—	120	18	.004	LIG. NI & NI GAS IMPACT	280	
—	101	18	.004	90	PAD FOLDING INCOMPLETE	—	121	18	.004	LIG. NI & NI GAS IMPACT	340	
4-5	102	18	.004	190		—	122	18	.004	LIG. NI & NI GAS IMPACT	325	
4-5	103	18	.004	195		—	123	18	.004	LIG. NI & NI GAS IMPACT	320	
4-5	104	18	.004	215		—	124	18	.004	LIG. NI & NI GAS IMPACT	315	
4-5	105	18	.004	185		—	125	18	.004	STATIC LIQUID NITROGEN	270	
4-5	106	18	.004	225		—	126	18	.004	STATIC LIQUID NITROGEN	180	
4-5	107	18	.004	190		—	127	18	.004	STATIC LIQUID NITROGEN	205	
4-5	108	18	.004	200		—	128	18	.004	STATIC LIQUID NITROGEN	225	
4-5	109	18	.004	210		—	129	18	.004	STATIC LIQUID NITROGEN	280	
4-5	110	18	.004	225		T4	130	18	.004	STATIC NITROGEN GAS	170	
4-5	111	18	.004	200		T4	131	18	.004	STATIC NITROGEN GAS	195	
4-5	112	18	.004	210		T4	132	18	.004	STATIC NITROGEN GAS	175	
4-5	113	18	.004	225		T4	133	18	.004	STATIC NITROGEN GAS	165	
4-5	114	18	.004	230		T4	134	18	.004	STATIC NITROGEN GAS	185	
4-5	115	18	.004	190		T4	135	18	.004	STATIC NITROGEN GAS	200	
						T4	136	18	.004	LIG. NI & NI GAS IMPACT	380	
						T4	137	18	.004	NITROGEN GAS IMPACT	300	

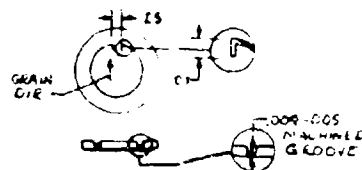
TABLE III (3 OF 3)  
VERNIER LIQUID OXYGEN BURST DIAPHRAGM  
BURST TEST RESULTS

DESIGN GR IDEN NO	TEST LAB IDEN NO	DIM A (INCHES)	DIM C (INCHES)	GRAIN DIA X BURST HINGE	BURST TEST CONDITIONS	BURST PRESS (PSI)	COMMENTS	DESIGN GR IDEN NO	TEST LAB IDEN NO	DIM A (INCHES)	DIM C (INCHES)	GRAIN DIA X BURST HINGE	BURST TEST CONDITIONS	BURST PRESS (PSI)	COMMENTS
T4	138	18	004 005		NITROGEN GAS IMPACT	300		T2	177	25	004 005		LIG NI & NI GAS IMPACT	420	
T4	139	18	004 005		LIG NI & NI GAS IMPACT	300		T2	178	25	004 005		LIG NI & NI GAS IMPACT	440	
T2	140	25	004 005		STATIC NITROGEN GAS	205		T2	179	25	004 005		LIG NI & NI GAS IMPACT	560	
T2	141	25	004 005		STATIC NITROGEN GAS	170		T3	146	25	007 008	⊥	STATIC NITROGEN GAS	370	
T2	142	25	004 005		STATIC NITROGEN GAS	185		T3	147	25	007 008	⊥	STATIC NITROGEN GAS	360	
T2	143	25	004 005		STATIC NITROGEN GAS	205		T3	148	25	007 008	⊥	STATIC NITROGEN GAS	360	
T2	144	25	004 005		STATIC NITROGEN GAS	175		T3	149	25	007 008	⊥	STATIC NITROGEN GAS	330	
T2	145	25	004 005		STATIC NITROGEN GAS	220		T3	150	25	007 008	⊥	STATIC NITROGEN GAS	350	
T1	153	25	004 005	⊥	STATIC NITROGEN GAS	215	27-24055-B	T3	151	25	007 008	⊥	STATIC NITROGEN GAS	345	
T1	154	25	004 005	⊥	STATIC NITROGEN GAS	195		T3	152	25	007 008	⊥	STATIC NITROGEN GAS	400	
T1	155	25	004 005	⊥	STATIC NITROGEN GAS	190		T3	159	25	007 008	⊥	NITROGEN GAS IMPACT	485	CRACKED HINGE
T1	156	25	004 005	⊥	STATIC NITROGEN GAS	190		T3	160	25	007 008	⊥	NITROGEN GAS IMPACT	460	CRACKED HINGE
T1	157	25	004 005	⊥	STATIC NITROGEN GAS	185		T3	161	25	007 008	⊥	NITROGEN GAS IMPACT	470	FAD SEPARATED AT THE HINGE
T1	158	25	004 005	⊥	STATIC NITROGEN GAS	195		T3	162	25	007 008	⊥	NITROGEN GAS IMPACT	450	SEVERELY CRACKED HINGE
T1	170	25	004 005	⊥	NITROGEN GAS IMPACT	330		T3	163	25	007 008	⊥	NITROGEN GAS IMPACT	500	CRACKED HINGE
T1	171	25	004 005	⊥	NITROGEN GAS IMPACT	260		T3	164	25	007 008	⊥	NITROGEN GAS IMPACT	500	SEVERELY CRACKED HINGE
T1	172	25	004 005	⊥	LIG NI & NI GAS IMPACT	460		T3	165	25	007 008	⊥	LIG NI & NI GAS IMPACT	300	SEVERELY CRACKED HINGE
T2	173	25	004 005		NITROGEN GAS IMPACT	320		T3	166	25	007 008	⊥	LIG NI & NI GAS IMPACT	420	CRACKED HINGE
T2	174	25	004 005		NITROGEN GAS IMPACT	260		T3	167	25	007 008	⊥	LIG NI & NI GAS IMPACT	420	CRACKED HINGE
T2	175	25	004 005		NITROGEN GAS IMPACT	260		T3	168	25	007 008	⊥	LIG NI & NI GAS IMPACT	440	CRACKED HINGE
T2	176	25	004 005		NITROGEN GAS IMPACT	240		T3	169	25	007 008	⊥	LIG NI & NI GAS IMPACT	420	CRACKED HINGE

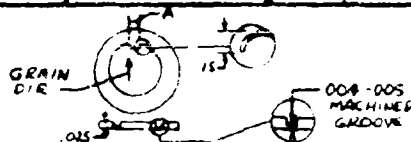
TABLE IV  
VERNIER LIQUID OXYGEN BURST  
DIAPHRAGM BURST TEST RESULTS

## NOTES:

- 1 SPEC. MAT'L 5052-H34 AL ALLOY
- 2 SPECIMENS WERE TESTED BY ONE OF THE FOLLOWING METHODS
  - A) SLOWLY INCREASING GASEOUS NITROGEN PRESSURE
  - B) IMPACTING SPECIMEN WITH NITROGEN GAS
  - C) PARTLY FILLING SPECIMEN WITH LIQUID NITROGEN AND SLOWLY INCREASING GASEOUS NITROGEN PRESSURE
  - D) PARTLY FILLING SPECIMEN WITH LIQUID NITROGEN AND IMPACTING SPECIMEN WITH NITROGEN GAS



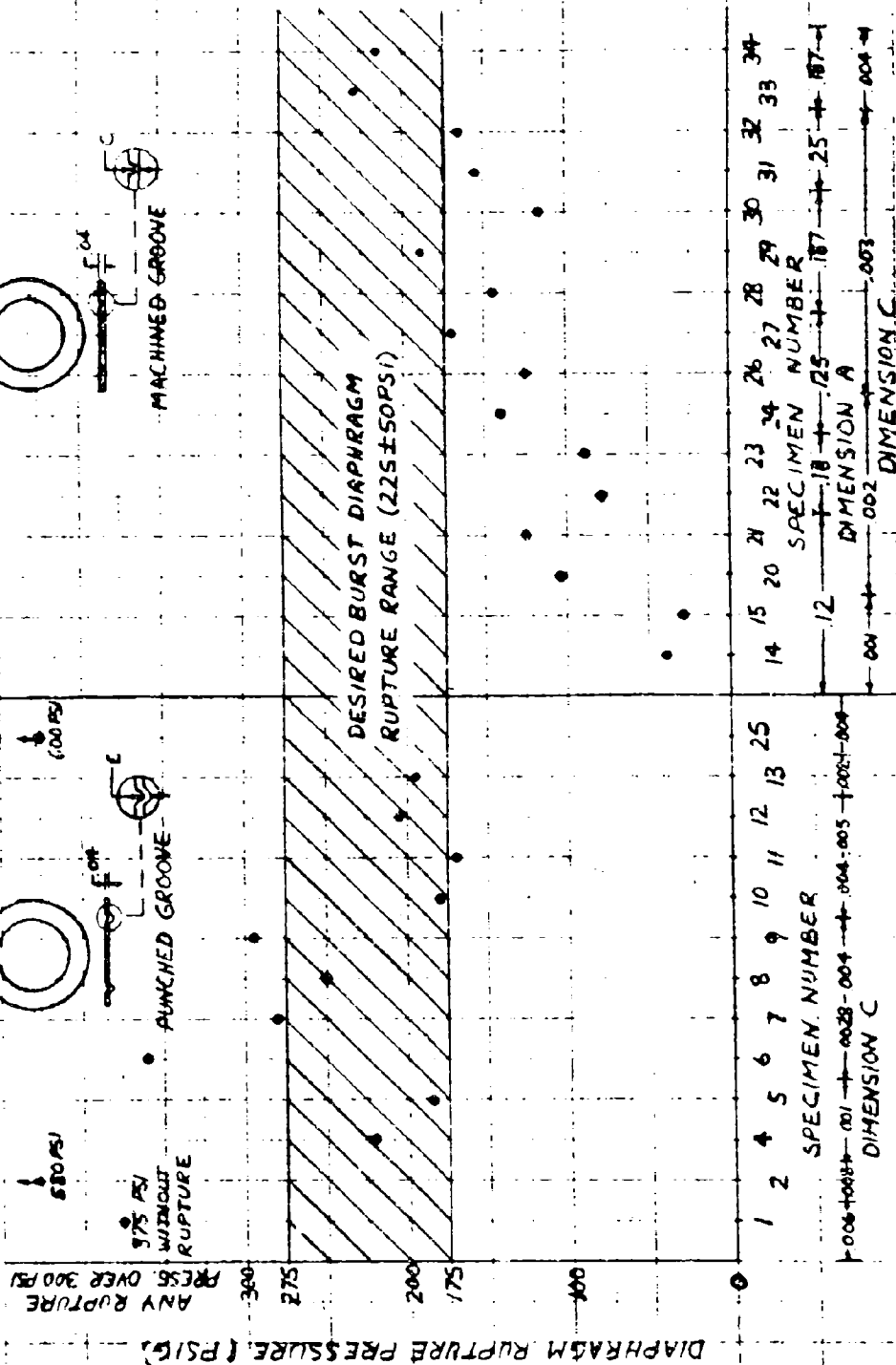
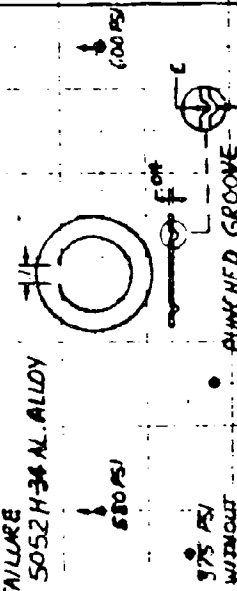
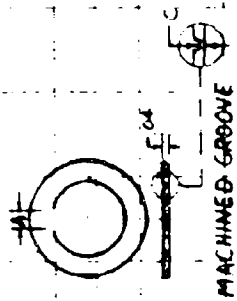
DESIGN GR. IDEN. NO.	TEST LAB IDEN. NO.	BURST TEST CONDITION	BURST PRESS (PSIG)	COMMENTS	DESIGN GR. IDEN. NO.	TEST LAB IDEN. NO.	BURST TEST CONDITION	BURST PRESS (PSIG)	COMMENTS
T1-1	190	STATIC NITROGEN GAS	140		T1-5	194	STATIC LIQ. NITROGEN	185	
T1-2	191	STATIC NITROGEN GAS	195		T1-6	195	STATIC LIQUID NITROGEN	185	
T1-3	192	NITROGEN GAS IMPACT	250		T1-7	196	LIQ. NI & NI GAS IMPACT	310	
T1-4	193	NITROGEN GAS IMPACT	250		T1-8	197	LIQ. NI & NI GAS IMPACT	390	
10	198	NITROGEN GAS IMPACT	320		10	201	LIQ. NI & NI GAS IMPACT	460	
10	199	NITROGEN GAS IMPACT	300		10	202	LIQ. NI & NI GAS IMPACT	410	
10	200	NITROGEN GAS IMPACT	280		10	203	LIQ. NI & NI GAS IMPACT	360	



DESIGN GR. IDEN. NO.	TEST LAB IDEN. NO.	DIM. A (INCHES)	BURST TEST CONDITION	BURST PRESS (PSIG)	COMMENTS	DESIGN GR. IDEN. NO.	TEST LAB IDEN. NO.	DIM. A (INCHES)	BURST TEST CONDITION	BURST PRESS (PSIG)	COMMENTS
10-3	204	25	NITROGEN GAS IMPACT	320		10-1	216	125	NITROGEN GAS IMPACT	300	
10-3	205	25	NITROGEN GAS IMPACT	280		10-3	209	25	LIQ. NI & NI GAS IMPACT	380	
10-3	206	25	NITROGEN GAS IMPACT	350		10-3	210	25	LIQ. NI & NI GAS IMPACT	340	
10-3	207	25	NITROGEN GAS IMPACT	310		10-3	211	25	LIQ. NI & NI GAS IMPACT	400	
10-3	208	25	NITROGEN GAS IMPACT	260		10-3	212	25	LIQ. NI & NI GAS IMPACT	340	
10-1	213	125	NITROGEN GAS IMPACT	300		10-1	217	125	LIQ. NI & NI GAS IMPACT	260	
10-1	214	125	NITROGEN GAS IMPACT	330		10-1	218	125	LIQ. NI & NI GAS IMPACT	330	
10-1	215	125	NITROGEN GAS IMPACT	240		10-1	219	125	LIQ. NI & NI GAS IMPACT	390	

GRAPH I  
N BURST DIAPHRAGM BURST TEST RESULTS

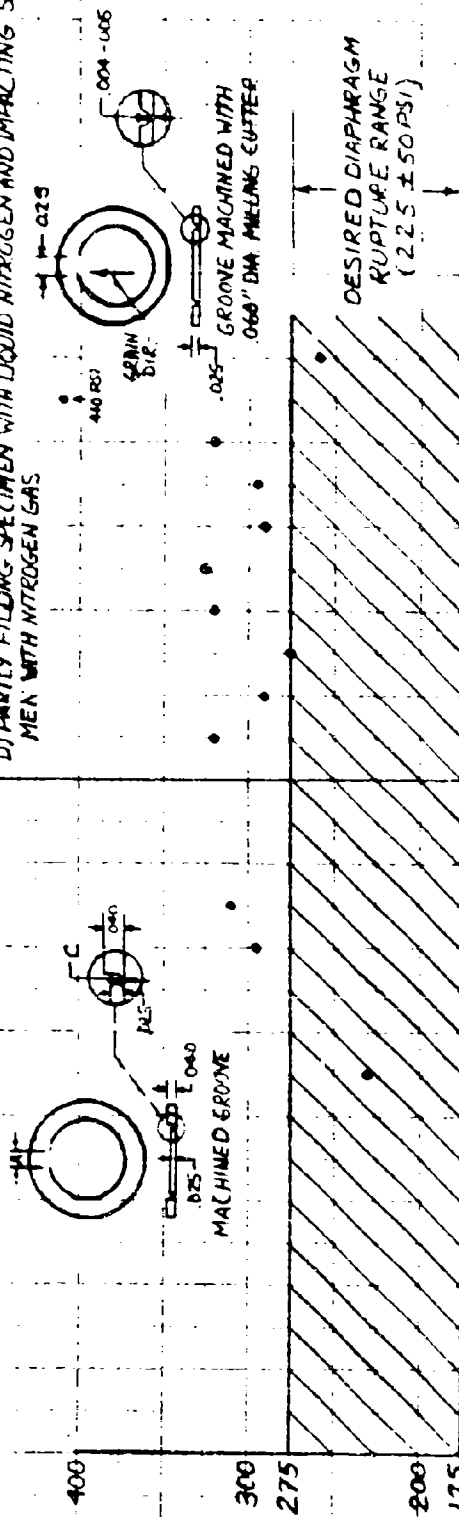
NOTES:  
1. SPEC. NO. 3 WAS A SPECIAL DUMPLED  
DIAPHRAGM PRESS TO 800 PSI WITHOUT FAILURE  
2. SPECIMENS WERE BURST TESTED BY FILLING  
SYSTEM WITH LIQUID NITROGEN AND SLOWLY PRES-  
SURIZING TO FAILURE



GRAPH II  
VERNIER LIQUID OXYGEN BURST DIAPHRAGM BURST TEST RESULTS

NOTE  
1. SPEC. 180-189 WERE BURST TESTED BY ONE OF THE FOLLOWING METHODS  
A) SLOWLY INCREASING GASEOUS NITROGEN PRESSURE  
B) IMPACTING SPECIMEN WITH NITROGEN GAS  
C) PARTLY FILLING SPECIMEN WITH LIQUID NITROGEN AND SLOWLY INCREASING GASEOUS NITROGEN PRESSURE  
D) PARTLY FILLING SPECIMEN WITH LIQUID NITROGEN AND IMPACTING SPECIMEN WITH NITROGEN GAS

NOTE  
1. SPECIMENS 35-47 WERE BURST TESTED BY FILLING SYSTEM WITH LIQUID NITROGEN AND SLOWLY PRESSURIZING THE SPECIMEN TO FAILURE  
2. ALL SPEC. MIN. OF SS52H 34 AL. ALLOY



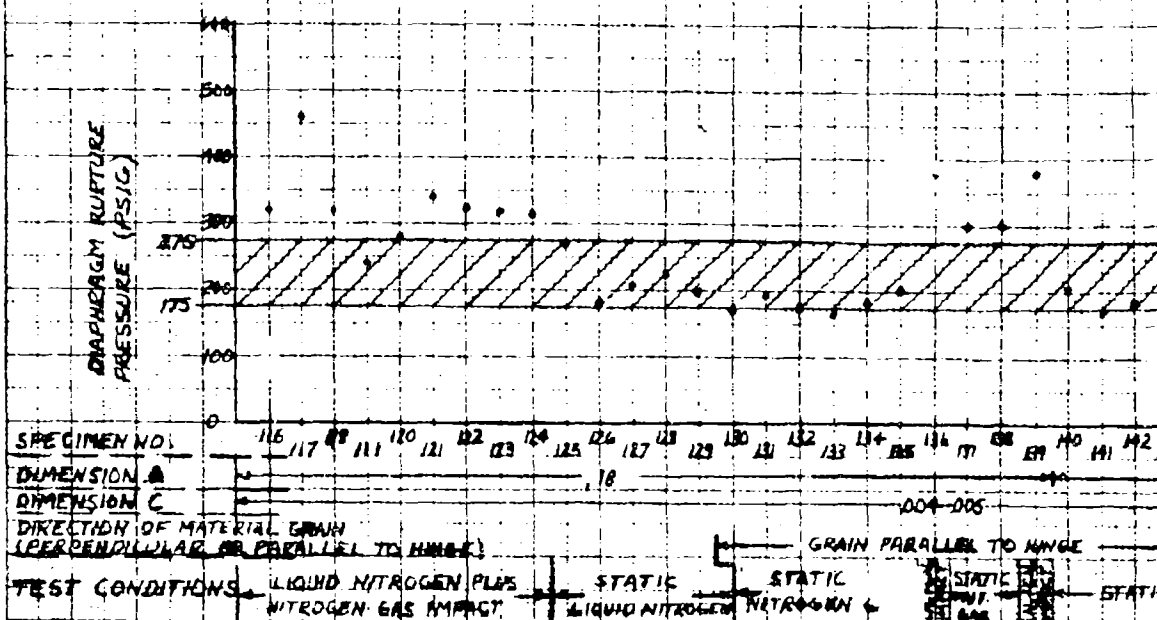
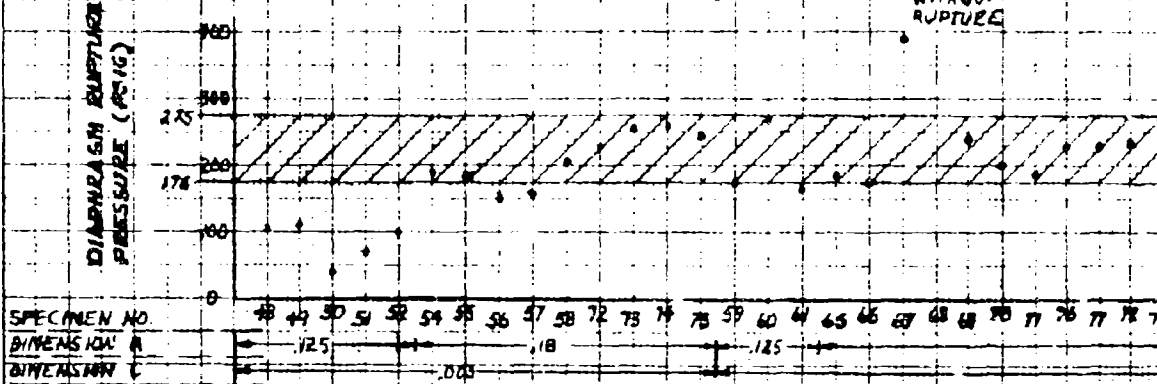
180 181 182 183 184 185 186 187 188 189  
SPECIMEN NUMBER  
STATIC NITROGEN GAS LIQUID NITROGEN GAS LIQUID NITROGEN GAS  
TEST CONDITIONS

35 36 37 38 39 40 41 42 43 44 45 46 47  
SPECIMEN NUMBER  
DIMENSION A 12 18  
DIMENSION C 003 004 005 006 007 008 009 010 011 012 013 014 015 016 017 018 019 020 021 022 023 024 025 026 027 028 029 030 031 032 033 034 035 036 037 038 039 040 041 042 043 044 045 046 047 048 049 050 051 052 053 054 055 056 057 058 059 060 061 062 063 064 065 066 067 068 069 070 071 072 073 074 075 076 077 078 079 080 081 082 083 084 085 086 087 088 089 090 091 092 093 094 095 096 097 098 099 100 101 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 127 128 129 130 131 132 133 134 135 136 137 138 139 140 141 142 143 144 145 146 147 148 149 150 151 152 153 154 155 156 157 158 159 160 161 162 163 164 165 166 167 168 169 170 171 172 173 174 175 176 177 178 179 180 181 182 183 184 185 186 187 188 189 190 191 192 193 194 195 196 197 198 199 200 201 202 203 204 205 206 207 208 209 210 211 212 213 214 215 216 217 218 219 220 221 222 223 224 225 226 227 228 229 230 231 232 233 234 235 236 237 238 239 240 241 242 243 244 245 246 247 248 249 250 251 252 253 254 255 256 257 258 259 260 261 262 263 264 265 266 267 268 269 270 271 272 273 274 275 276 277 278 279 280 281 282 283 284 285 286 287 288 289 290 291 292 293 294 295 296 297 298 299 300 301 302 303 304 305 306 307 308 309 310 311 312 313 314 315 316 317 318 319 320 321 322 323 324 325 326 327 328 329 330 331 332 333 334 335 336 337 338 339 340 341 342 343 344 345 346 347 348 349 350 351 352 353 354 355 356 357 358 359 360 361 362 363 364 365 366 367 368 369 370 371 372 373 374 375 376 377 378 379 380 381 382 383 384 385 386 387 388 389 390 391 392 393 394 395 396 397 398 399 400 401 402 403 404 405 406 407 408 409 410 411 412 413 414 415 416 417 418 419 420 421 422 423 424 425 426 427 428 429 430 431 432 433 434 435 436 437 438 439 440 441 442 443 444 445 446 447 448 449 450 451 452 453 454 455 456 457 458 459 460 461 462 463 464 465 466 467 468 469 470 471 472 473 474 475 476 477 478 479 480 481 482 483 484 485 486 487 488 489 490 491 492 493 494 495 496 497 498 499 500 501 502 503 504 505 506 507 508 509 510 511 512 513 514 515 516 517 518 519 520 521 522 523 524 525 526 527 528 529 530 531 532 533 534 535 536 537 538 539 540 541 542 543 544 545 546 547 548 549 550 551 552 553 554 555 556 557 558 559 560 561 562 563 564 565 566 567 568 569 570 571 572 573 574 575 576 577 578 579 580 581 582 583 584 585 586 587 588 589 590 591 592 593 594 595 596 597 598 599 600 601 602 603 604 605 606 607 608 609 610 611 612 613 614 615 616 617 618 619 620 621 622 623 624 625 626 627 628 629 630 631 632 633 634 635 636 637 638 639 640 641 642 643 644 645 646 647 648 649 650 651 652 653 654 655 656 657 658 659 660 661 662 663 664 665 666 667 668 669 670 671 672 673 674 675 676 677 678 679 680 681 682 683 684 685 686 687 688 689 690 691 692 693 694 695 696 697 698 699 700 701 702 703 704 705 706 707 708 709 710 711 712 713 714 715 716 717 718 719 720 721 722 723 724 725 726 727 728 729 730 731 732 733 734 735 736 737 738 739 740 741 742 743 744 745 746 747 748 749 750 751 752 753 754 755 756 757 758 759 760 761 762 763 764 765 766 767 768 769 770 771 772 773 774 775 776 777 778 779 780 781 782 783 784 785 786 787 788 789 790 791 792 793 794 795 796 797 798 799 800 801 802 803 804 805 806 807 808 809 810 811 812 813 814 815 816 817 818 819 820 821 822 823 824 825 826 827 828 829 830 831 832 833 834 835 836 837 838 839 840 841 842 843 844 845 846 847 848 849 850 851 852 853 854 855 856 857 858 859 860 861 862 863 864 865 866 867 868 869 870 871 872 873 874 875 876 877 878 879 880 881 882 883 884 885 886 887 888 889 890 891 892 893 894 895 896 897 898 899 900 901 902 903 904 905 906 907 908 909 910 911 912 913 914 915 916 917 918 919 920 921 922 923 924 925 926 927 928 929 930 931 932 933 934 935 936 937 938 939 940 941 942 943 944 945 946 947 948 949 950 951 952 953 954 955 956 957 958 959 960 961 962 963 964 965 966 967 968 969 970 971 972 973 974 975 976 977 978 979 980 981 982 983 984 985 986 987 988 989 990 991 992 993 994 995 996 997 998 999 1000

# GRAPH VERNIER LIQUID OXYGEN

## NOTES:

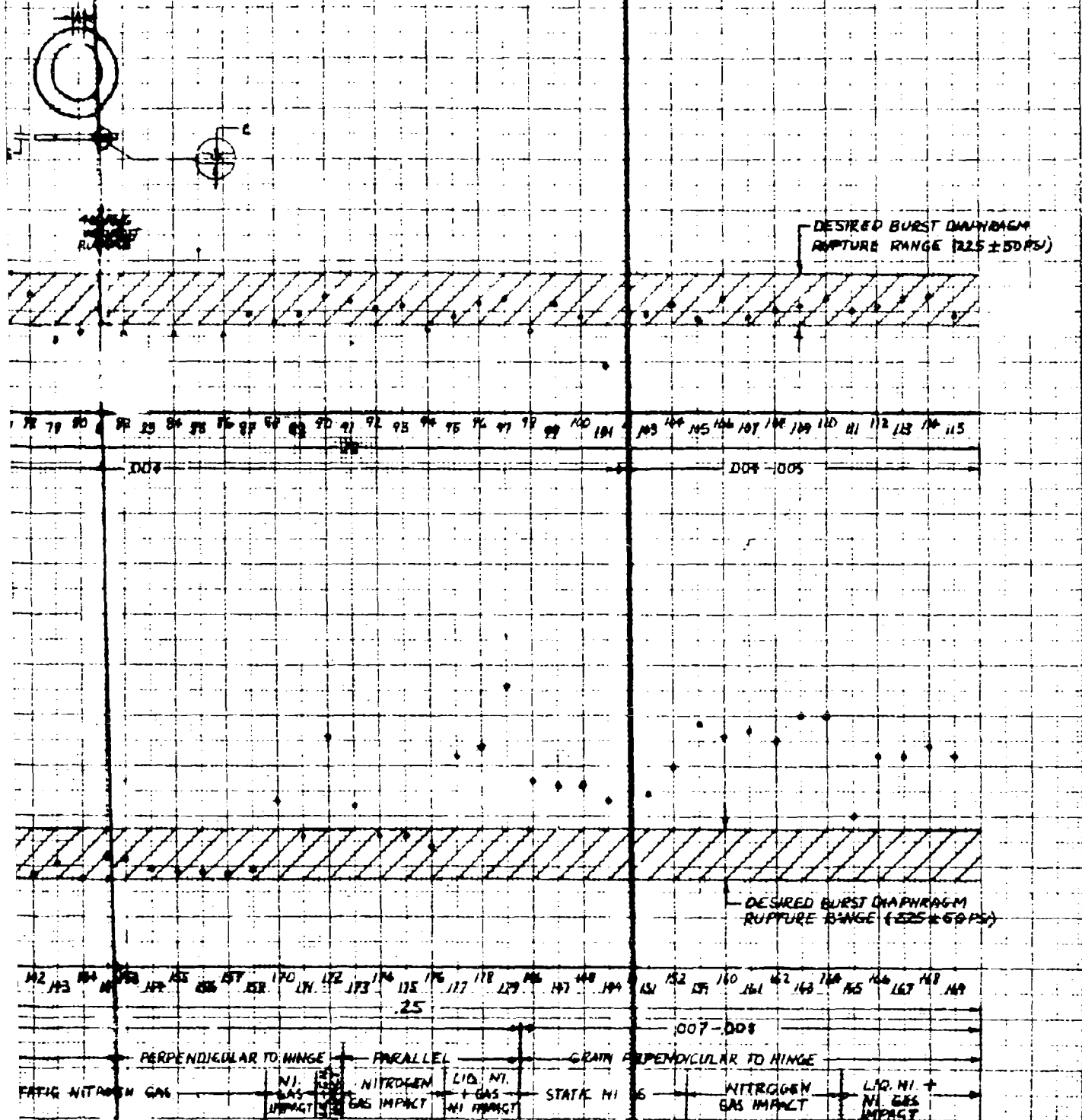
1. ALL SPECIMENS WERE FABRICATED FROM 5052H-34 ALUMINUM ALLOY
2. SPECIMENS 48 TO 116 PLUS 125 TO 130 WERE BURST TESTED BY FILLING THE SYSTEM WITH LIQUID NITROGEN AND SLOWLY PRESSURIZING THE SPECIMEN TO FAILURE. THE REMAINING SPECIMENS WERE BURST TESTED BY ONE OF THE FOLLOWING METHODS:
  - A) SLOWLY INCREASING GASEOUS NITROGEN PRESSURE
  - B) IMPACTING SPECIMEN WITH NITROGEN GAS
  - C) PARTLY FILLING SPECIMEN WITH LIQUID NITROGEN AND SLOWLY INCREASING GASEOUS NITROGEN PRESSURE
  - D) PARTLY FILLING SPECIMEN WITH LIQUID NITROGEN AND IMPACTING SPECIMEN WITH NITROGEN GAS (EXCEPT SPECIMEN 116-120 WHICH WERE FULL OF LIQUID NITROGEN)
3. CONCERN WITH GRAIN DIRECTION BEGAN WITH SPECIMEN NO. 130



A



GRAPH OF  
OXYGEN BURST DIAPHRAGM BURST TEST RESULTS



6

GRAPH IV

NOTES: SC52-H34 AL ALLOY

THE SPECIMENS WERE TESTED BY ONE OF THE FOLLOWING METHODS:

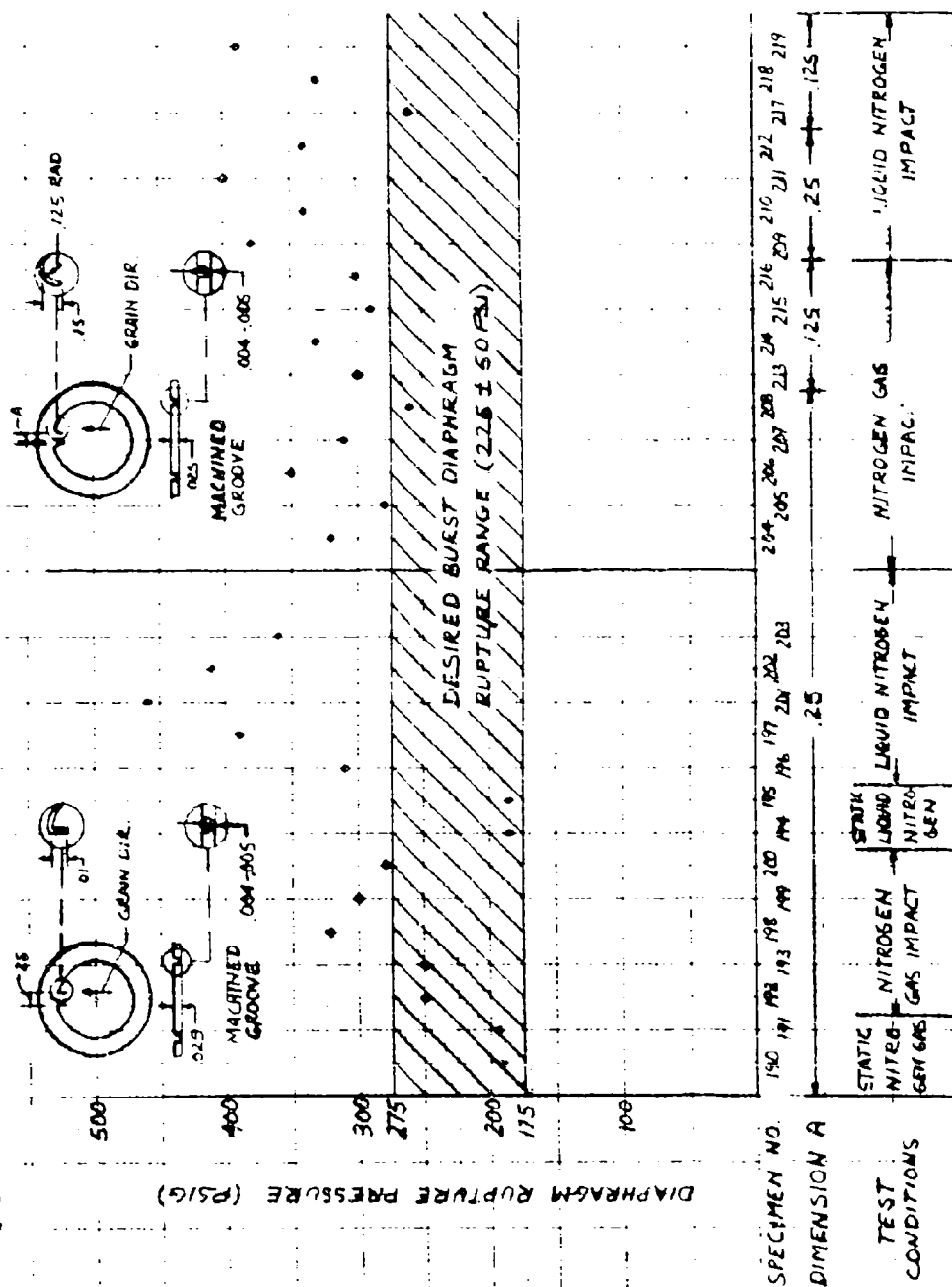
A) SLOWLY INCREASING GASEOUS NITROGEN PRESSURE

8) IMPACTING SPECIMEN WITH NITROGEN GAS

C) PARTLY FILLING SPECIMEN WITH LIQUID NITROGEN AND SUMPLY  
USING THE CASSEOUS NITROGEN PRESSURE

INCREASING GASEOUS WITH ALUMINUM PRESSURE  
THE EFFECTS OF FILLING SPECIMEN WITH LIQUID NITROGEN AND IMPACT-

ING SPECIMEN WITH NITROGEN GAS



CPFC-MEM NO.

### DIMENSION A

TEST  
CONDITION

## CONDITIONS

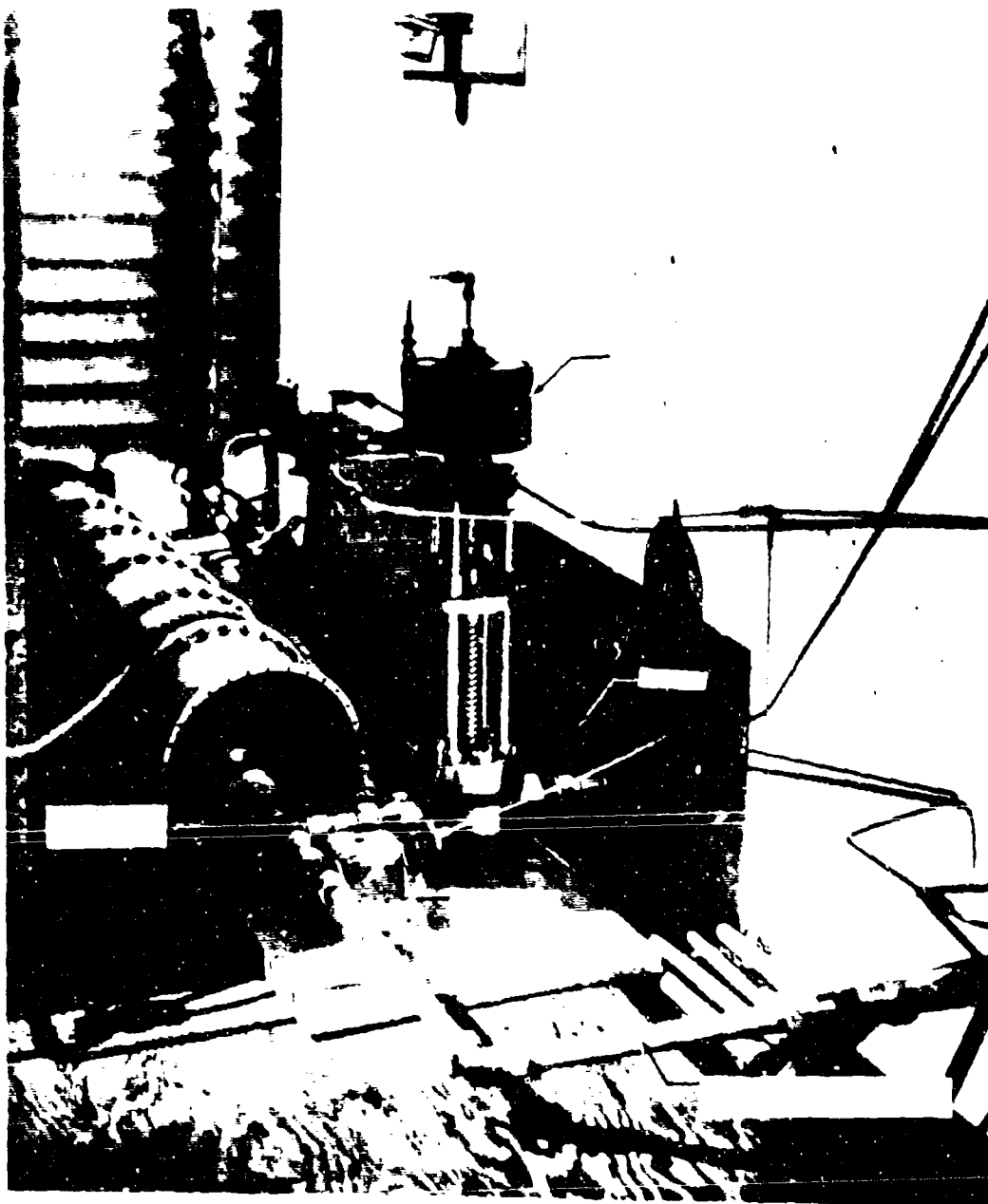


FIGURE 1

BURST TEST SETUP



FIGURE 2

BURST TEST CONTROL PANEL



FIGURE 3

WATER FLOW SETUP